Abstract

A method for monitoring a high-resistivity reservoir rock formation (2) below one or more less resistive formations (3). The method includes transmitting an electromagnetic signal (S) propagating from near a seafloor or land surface (1) by means of an electromagnetic transmitter (5) powered by a voltage signal generator (G). The electromagnetic signal (S) propagates from the seafloor (1) and is guided along a conductive string (7) to the high-resistive formation (2), and propagates as a guided-wave electromagnetic signal (S2) at a relatively higher speed (V2) inside the high-resistivity formation (2) than a propagation speed (V3) in the less resistive formations (3). The guided-wave electromagnetic signal (S2) gives rise to an upward refracting electromagnetic signal (R3) having the relatively lower propagation speed (V3) in the less resistive formations (3) and having an exit angle nearer to the normal (N) to the interface between the high-resistivity formation (2) and the lower-resistivity formation (3), and gives rise to a steeply rising refraction wave front (F3). The refracted electromagnetic wave front (F3) includes refracted electromagnetic signals (R3) detected along an array of sensor antennas (6a, 6b, 6c, ..., 6k, ..., 6n) positioned along the seafloor. The array having a direction away from the transmitter (5).

Version with Marking to Show Changes Made

Abstract

A method for monitoring a high-resistivity reservoir rock formation (2) below one or more less resistive formations ~~(3), comprising the following steps: Transmitting~~ (3). The method includes transmitting an electromagnetic signal (S) propagating from near a seafloor or land surface (1) by means of an electromagnetic transmitter (5) powered by a voltage signal generator (G).

The electromagnetic signal (S) propagates from the seafloor (1) and is guided along a conductive string (7) to the high-resistive formation (2), and propagates as a guided-wave electromagnetic signal (S2) at a relatively higher speed (V2) inside the high-resistivity formation (2) than a propagation speed (V3) in the less resistive formations (3).

The guided-wave electromagnetic signal (S2) gives rise to an upward refracting electromagnetic signal (R3) having the relatively lower propagation speed (V3) in the less resistive formations (3) and having an exit angle nearer to the normal (N) to the interface between ~~said~~ the high-resistivity formation (2) and the lower-resistivity formation (3), and gives rise to a steeply rising refraction wave front (F3).

The refracted electromagnetic wave front (F3) ~~comprising~~ includes refracted electromagnetic signals (R3) ~~is~~ detected along an array of sensor antennas (6a, 6b, 6c, ..., 6k, ..., 6n) positioned along the ~~seafloor, the~~ seafloor. The array having a direction away from the transmitter (5).

~~In a preferred embodiment of the invention, the electromagnetic transmitter (5) comprises an antenna (50) transmitting the electromagnetic signal (S) to an upper end (70 U) of an electrically conductive string (7), e.g. a steel casing or liner, the upper end (70 U) being arranged near said seafloor (1).~~